# Appendix I-B
# Water Quality Treatment Design Storm, Volume, and Flow Rate

**Water Quality Design Storm:** A 24-hour storm with a 6-month return frequency(a.k.a., 6-month, 24-hour storm). The 6-month, 24-hour storm can be estimated as 72% of the 2-year, 24-hour rainfall amount for areas in western Washington.

**Water Quality Design Storm Volume:** The volume of runoff predicted from a 6-month, 24-hour storm. **Alternatively, the 91st percentile, 24-hour runoff volume indicated by an approved continuous runoff model.**

Facilities such as wetpools are sized based upon either: 1) the volume of runoff produced by the water quality design storm, or 2) the 91st percentile, 24-hour runoff volume indicated by an approved continuous runoff model. They are the same size whether they precede, follow, or are incorporated (i.e., combined detention and wetpool facilities) into detention facilities for flow control. The water quality design storm volume can be computed using the SCS (NRCS) curve number equations in Volume III, Chapter 2.

Unless amended to reflect local precipitation statistics, the 6-month, 24-hour precipitation amount may be assumed to be 72 percent of the 2-year, 24-hour amount. Precipitation estimates of the 6-month and 2-year, 24-hour storms for certain towns and cities are listed in this appendix. For other areas, interpolating between isopluvials for the 2-year, 24-hour precipitation and multiplying by 72% yields the appropriate storm size. Isopluvials for 2-year, 24-hour amounts for Western Washington are reprinted in Volume III.

**Background for the Water Quality Design Storm and Volume:**

The 6-month, 24-hour storm was the water quality design storm in the 1992 Stormwater Management Manual for the Puget Sound Basin. It was originally chosen when developing the Puget Sound manual based upon a judgement of when the incremental costs of additional treatment capacity exceed the incremental benefits. In particular, the cost of providing the increased detention volume for a wet pond was not seen as cost-effective when compared with the incremental amount of annual stormwater volume that would be effectively treated. Rainfall data from Sea-Tac was used in the original analysis.

Runoff flow rates for a number of different development scenarios have been estimated and compared using KCRTS and the Santa Barbara Urban Hydrograph Method (SBUH). KCRTS was used for this comparison because it provides flow rates in 15-minute time increments. The WWHM only provides 1-hour increments. A 15-minute increment data set is more comparable to the 10-minute time step of the SBUH analysis. It is expected that a comparison between the WWHM and SBUH would provide similar results as the KCRTS vs. SBUH comparison.

A spreadsheet can be used to statistically analyze the long time series of runoff predicted by KCRTS. That analysis shows that only 2.5 to 3% of the annual runoff volume is discharged at a rate that equals or exceeds the peak 10 minute runoff predicted by SBUH for the water quality design storm. This is a second indicator that the 1992 manual water quality design flow rate is too conservative if the intent is to provide effective treatment for 91% of the runoff volume.

Using the same spreadsheet, a flow rate can be identified above which only 9% of the annual runoff volume is discharged. However, that flow rate is still too conservative if the intent is to provide effective treatment for 91% of the annual runoff volume. An off-line facility that is designed to receive and effectively treat a flow rate at or below which 91% of the annual volume is discharged, will actually treat 97 to 98% of the annual runoff volume. This occurs because a flow splitter continues to send a portion (in this instance, the flow rate above which only 9% of the runoff volume is discharged) of the higher flow rates to the treatment facility. To treat 91% of the annual runoff volume, a flow splitter should start to bypass incremental portions of flow rates above a rate at which 72 to 80% of the runoff volume is discharged. The above percentage changes with project characteristics, most notably the percent imperviousness of a project.

This flow rate, which a flow splitter must route to the treatment facility in an off-line mode, becomes the water quality design flow rate. This rate is sometimes referred to as the 91% flow rate in the manual. At the time of publication of the 2001manual, the WWHM did not identify this water quality design flow rate directly for the user. The user would have to take the output of the WWHM and perform a statistical analysis of the data set to determine the flow rate associated with treating 91% of the runoff volume. However, the WWHM only provides flow rates in 1-hour time increments. Further, it is more appropriate to use 15-minute time increments for facilities that perform their treatment function with short hydraulic residence times. Therefore, that flow rate would have to be increased by a factor to convert the hourly flow rate to an equivalent 15-minute flow rate.

WWHM2 now provides an estimate of the water quality design flow rate in 1-hour and 15-minute time steps, and for off-line and on-line facilities.

~~*Determination of the Water Quality Design Flow Rate for a project:*~~

~~Rather than leaving these calculations to the user of the manual, it is Ecology's intent to have the WWHM amended to provide the water quality design flow rate directly to the user. Until such time as the WWHM does that, a method to estimate the water quality design flow rate has been provided. That method is to multiply the 2-year return frequency flow rate, identified by the WWHM, for the post-development condition by a factor that varies with the percent effective impervious surface of the project. A table containing the scale factors is included in Chapter 4 of Volume V. The factor also includes an adjustment intended to convert the hourly flow rates to 15-minute flow rates.~~

*Water Quality Design Flow Rate Downstream of Detention Facilities:*

The 91% flow rate downstream of detention will be significantly smaller than upstream of detention. The detention facilities, which are fitted with flow-restricting orifices, significantly change the distribution of flow rates. The flow duration standard requires that the total amount of time that flows are discharged above ½ of the 2-year flow not increase. There is a much greater volume of surface runoff post-development than pre-development. Therefore, an extra volume of water must be discharged at rates below ½ the 2-year rate for extended periods of time.

The result of this redistribution is that downstream treatment facilities will operate for extended periods of time at flow rates at or near their design flow rate. For downstream facilities sized for the 91% flow rate this will achieve less annual treatment removal efficiency than that achieved by facilities located upstream. Upstream treatment facilities see more variable flow rates, and presumably, operate more efficiently at lower flow rates than the design flow rate. In addition, downstream detention facilities would have a hard time meeting the annual TSS removal performance goal of 80% removal. They also would need intensive maintenance as they are treating the same volume of water through substantially less treatment area and volume.

In order to compensate for this, the water quality design flow rate, downstream of detention facilities is the 2-year return frequency flow from a detention facility that is designed to meet the flow duration standard. The 2-year frequency flow rate represents a flow rate that will effectively treat a greater percentage of the annual runoff volume than 91%. In addition, flow rate-based treatment facilities downstream of detention should only be designed to be on-line facilities. These downstream water quality design flow rates are 3.5 times smaller than upstream, off-line flow rates, and 6.5 times smaller than  upstream, on-line flow rates ~~It still represents a significant – on the order of 3 times – facility size reduction compared to a facility located upstream.~~

This requirement applies to treatment facilities that are sized based upon a short hydraulic residence time or velocity.  This would include biofiltration swales, oil/water separators, and sand/media filters that are not preceded by a significant storage reservoir (i.e., above the filtration unit).  Where a sand/media filter is preceded by a significant equalization/storage reservoir, it may be sized using a continuous runoff model and a volume-based approach to achieve the 91% or 95% volume targets (whichever is applicable).

*Impact on Design Criteria:*

The 1992 design criteria for some public domain treatment facilities had been intended to apply to the water quality design flow rate in the 1992 manual.  The new water quality design flow rate is a fraction of that old rate.  If the 1992 design criteria were retained and applied at the new water quality design flow rate, new treatment facilities would be that same fraction of the size of existing treatment facilities.  This would not be a prudent action since it is not known whether existing treatment facilities can meet the proposed performance goals.  Until more reliable monitoring information to judge the performance of existing treatment facilities exist, the prudent action is to adjust their design criteria such that they continue to be built to approximately the same size as they should have been built using the 1992 design criteria and design flow rates.  ~~This has been done for swales, strips, and oil/water separators.  The design criteria adjustments are summarized below, and should appear in the chapter for each type of facility in Volume V.~~

| ~~Treatment Type~~ | ~~1992 Criteria~~ | ~~2001 Criteria~~ |
|---|---|---|
| ~~Basic & Wet Biofiltration Swale~~ | ~~9 minutes~~ | ~~22 minutes~~ |
| ~~Continuous Inflow Biofiltration Swale~~ | ~~N/A~~ | ~~44 minutes~~ |
| ~~Filter Strips~~ | ~~9 minutes~~ | ~~22 minutes~~ |
| ~~Oil/Water Separators~~ | ~~Q = 1992 flow rate~~ | ~~Q = 2.15x new water quality design flow rate~~ |